"Redesign of electrical installations to maximize the use of Photo Voltaic (PV) cells at the end use of consumers in Kuwait"

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Abstract - *A new idea of redesigning the electrical installations inside residential premises is presented in this paper. The idea is based on having two separate circuits' installations. The first is A.C circuit which can be served by electric grid at standard operating voltage of 230 volts. While the second is D.C circuit being feed directly from the PV cells to meet the demand of all electrical appliances operated at tapered voltage between 12, 24 and 48 volts. The problem of unavailability of PV cell generation during the absence of sun is discussed and solved by introducing a smart interface between the power utility and the consumer having this micro generation PV cells. Smart bidirectional kWh energy meter is used to register the energy consumed by the consumer and the energy being produced by PV cells owned by the consumer himself. In this paper ten years were used to asses the advantages of using this method in Kuwait power systems. Besides the reduction in expansion cost for the power system, a significant release of system capacity was also assessed. Computer software was used to perform the load flow for typical days of the year to show clearly the behavior of the system under these new conditions. As a result of applying this new technique, generator units, transformers, over headlines and under ground cables capacity were released. The voltage drop and energy losses through the power system network were reduced as result of reducing the current flow in them. A comparison between continuing to meet the expansion of the system in Kuwait with conventional electric power equipment and using new technique is presented in this paper.*

1. Introduction:

In Kuwait the problem of power shortage, and even programmed power cut, has been recently remarked due to the growing demand and the excessive losses of electrical energy. Potential energy efficiency improvements and on-peak reduction were highly recognized in several local studies and researches[1].

The Ministry of Electricity and Water (MEW), is the only utility responsible for generation, transmission and distribution of electricity in Kuwait. It has to meet the growing demand for electricity by building new power plants that require high investments. The work in this paper focuses on the use of PV cells for residential sector and the evaluation of their impact on the peak demand and energy consumption from 2010 to 2020. There will be a significant reduction in peak maximum demand during the day and especially during summer in Kuwait, where in summer, peaks are almost twice and a half of the winter peaks. This is very important as the maximum generation of PV cells as the sun is nearly perpendicular on the PV cell panels during the summer noon. During the summer 2008, the maximum demand was nearly 9710 MW. If the annual growth in Kuwait power system is forecasted on average of five percent for the next ten years, then nearly half of this can be directly fed using PV cells based on this new idea. The savings in Kuwait power system were assessed as the saving in cost of generation, in transmission at 300 KV, and the cost of distribution networks

The total installed capacity of MEW thermal power plants was 11641 MW in 2008 [2]i. Table 1 shows the development of installed capacity, maximum demand, and energy exported (sent out) to the grid and the load factor. Peak demand in Kuwait increased from 4350 MW in 1994 to 9710 MW in 2008, with an average growth rate about 6%. Based on MEW Statistical Year Book, the maximum load share of residential consumer reached 10.91 KW in 2008. Thus, MEW is facing great challenges; first to satisfy the requirements of large investments for building new power plants, and second to take the necessary actions for rational use of energy and decrease the rate of electricity demand [2].

Table 1: Installed Capacity (I.C) of power plants, grid stations, maximum demand and load factor:

Year	Inst. Cap. of Gen. MW	Total No. of Subst. 300/ 132 /33kV	Inst. Cap. Of Trans. (MVA)	Ratio (I.C of Trans. /Gen.	Max. Demand (MW)	Load Factor (%)
1994	6898	1069	42188	6.11	4350	59.8
1996	6898	1145	43083	6.24	5200	55.8
1998	7389	1200	46013	6.22	5800	59.1
2000	9189	1224	46763	5.08	5800	57.1
2002	9189	1358	50573	5.50	7250	57.2
2004	9689	1448	57523	5.93	7750	60.6
2006	10189	1508	59253	5.81	8900	61.1
2008	11641	1604	63333	5.44	9710	60.7

The factors given in Table 1 also show the ratio of the installed capacity of transformers to that of the generators which was about six to one during the previous decade (1994-1998) and then reduced to five and a half to one in this decade (1998-2008). The above table's information is well clear in the MEW 2009, Statistical yearbook. This is usually the case for the most of the power transformer which can be easily understood from the Kuwait modeling single line diagram shown in Figure 2. For instance to meat a load of 1000 MW on the low voltage side (0.4 KV), it is required to install 1250 MW of generators (25 % as reserve). The generators terminal voltages are around 15 KV which implies to step up this voltage to 132 KV and again 300 KV in order to transmit this power over long distances and then to step down again to 33 KV or 11 KV for the purposes of primary distribution of power. This can be met by what is known as firm capacity. And in this model it is double 3 to two i.e. the need is 2 x 3 x 1000/2 = 3000 MVA of transformers. The same thing in the main substations, the need is for 2000 MVA of transformers as two similar transformers are installed in each substation, while for the secondary distribution, the need is for 50 % loaded transformers are usually installed to allow for future expansion. That means another of 2000 MVA of transformer must be used in the secondary distribution and the ratio in this case will be 7000/1250 = 5.6.

For generation plants

Let

S_{TG}= Installed Capacity of generators in MW

C_{TG}= Total cost of generator plants in U.S $

C_{KWG} = Average cost of one KW in U.S dollars in generation plants

From Table 1, consider the year 2008 as base year then

$$S_{TG} = 11\ 641 \text{ MW}$$

As most of generator are using gas and oil as input fuel, then the average capital cost is (320+220)/2= 270 KD/KW [1]. Note one KD is equivalent to 3.46 US$. Then the cost of 1 KW is equal to 934 US$ (this includes the cost of generator unit set, switchgear, other substation equipment and the cost of land). This is given in Table 2.

Then

$$C_{TG}= S_{TG} \times C_{KWG}$$
$$= 11\ 641 \times 934 \times 1000=10\ 872 \text{ US\$ M}$$

Table 2: Cost of different generation types in Kuwait [1].

	Capital cost KD/KW	Operating cost KD/KW/Y	Life Years	Type of Fuel
Open Cycle Gas	220	12	20	Gas
Turbine power plant (OCGT)	220	18	20	Gas and Oil
Gas Turbine	320	10	20	Gas
Combined Cycle power plant (CCGT)	320	15	20	Gas and Oil
Reheat Steam power plant (RHSPP)	500	6	30	Low Fuel Oil (LFO)
Photovoltaic PV 2010	1900	2	20	
Photovoltaic PV2020	900	2	20	

Table 2 gives the current price of Photovoltaic for Crystalline Silicon and Thin Films/Concentrators, while the price will be much reduced in the year 2020 as a result of using Thin Films/Concentrators and New technologies.

For transmission substations

Let

S_{TP}= Installed Capacity of power transformer in MVA

C_{TP}= Total cost of power transformers in U.S $

C_{KVAT} = Average cost of one KVA in U.S dollars in transmission system

From Table 1, consider the year 2008 as base year then

$$S_{TP}=63333 \text{ MVA}$$

If the cost of 1 KVA on average is equal to 50 US$ (this includes the cost of power transformer, switchgear, other substation equipment and the cost of land).

Then

$$C_{TP}= S_{TP} \times C_{KVAT}$$
$$= 63333 \times 50\ 000=3\ 166 \text{ US\$ M}$$

Table 3 gives statistical data [2] of the installed capacity for distribution transformers as classified by MEW into indoor and outdoor substations.

Table 3: Installed Capacity (I.C) of distribution transformers:

Year	Indoor Substations (11/0.433 kV)		Outdoor Substations and UDS		Max. Demand. (MW)
	No.	Capacity (MVA)	No.	Capacity MVA	
1998	5057	7585	3082	2989	5800
2000	5335	8536	3340	3110	5800
2002	5658	9618	3659	3512	7250
2004	6224	11203	4218	3950	7750
2006	6680	1269	4941	4509	8900
2008	7043	14086	5800	5650	9710

For distribution substations

Let

S_{Tin} = Installed Capacity of distribution transformer as indoor in MVA

S_{Tod}= Installed Capacity of distribution transformer as outdoor in MVA

C_{Td}= Total cost of distribution transformers in U.S $

C_{KVAD} = Average cost of one KVA in U.S dollars in distribution system.

From Table 2, consider the year 2008 as base year, then

S_{Tin}=14086 MVA and S_{Tod}=5650 MVA

If the cost of 1 KVA on average is equal to 30 US$ (this includes the cost of distribution transformer, switchgear, other substation equipment and the cost of land).

Then $C_{Td} = (S_{Tin} + S_{Tod})\, C_{KVAD}$

= (14086 +5650) x 30 000=592 US$ M

To have an idea about the key factors in terms of electrical equipments which dominate the capital expenditure in the Kuwaiti power system, Table 4 gives the historical development of underground cables and overhead lines those were needed to meet the maximum demand for the years (1994 to 2008)[2].

To take into account the cost of under ground cables and overhead lines assume the following:

- Cost of 1 km of underground cable (300KV and 132 KV) = 1.3 US$ M
- Cost of 1 km of underground cable (33 KV) = 0.06 US$ M
- Cost of 1 km of overhead lines (300KV and 132 KV) = 0.4 US$ M
- Cost of 1 km of overhead lines (33 KV) = 0.02 US$ M

Using the information given in Table 4:

The cost of underground cable (300KV and 132 KV)

= 1.3 x (216+2556)

=3 603 US$ M

The cost of underground cable (33 KV)

= 0.06 x (1531) = 92 US$ M

Table 4: Development of Transmission System and Maximum Demand [2].

Year	Length of underground cables km			Length of overhead lines km			Max. Demand MW
	300 kV	132 kV	33 kV	300 kV	132 kV	33 kV	
1994	167	1987	1430	395	1175	1231	4350
1996	167	2001	1455	608	1218	1341	5200
1998	179	2074	1494	608	1482	1393	5800
2000	179	2132	1509	608	1482	1557	6450
2002	203	2368	1517	608	1510	1563	7250
2004	216	2461	1517	608	1553	1612	7750
2006	216	2484	1519	608	2098	1788	8900
2008	216	2556	1531	712	2162	1827	9710

The cost of overhead lines (300KV and 132 KV)

= 0.4 x (712+2162) =1150 US$ M

Then the total cost of the power system is:

=10 872 + 3 166 + 592 +3 603 +92 + 1150

= 19 475 US$ M

If Kuwait power system was to meet a maximum demand load of 9710 MW in the year 2008, then the cost of one KW load was 19 475 /9710= 2005 US$/KW. By comparing this cost with the expected PV Photovoltaic in 2010 -given in Table 2 – it is seems that the conventional way is higher than using PV cells. Besides if the operating costs were taken into account then PV solution will be superior. Besides the PV cells prices are going down in the future as given in Table 2, which is expected to be 900 US$/KW.

2. Forecasted Installed Capacity and Maximum Demand

Based on the historical data for the last ten years simplified calculations for the forecasted installed capacity and maximum demand for Kuwait power system was performed as given in Table 5. The average growth rate of the maximum demand for the years between 2010 and 2020 was considered to be 5% and for the installed capacity was 4%.

The ratio between installed capacities given in Table 5 was increased from 5.59 in the first year 2010 to 6.16 in the final year 2020 to allow for tie connection between Arab Gulf Countries and the need to install new transformers to reach the tie connection voltage operating on 400 KV. The installed capacity of transformers will be expected to increase in the first stage by 12 x 765=9 180 MVA by the end of the year 2012 (.section 6).

Table 5: Forecasted Installed Capacity for the generators and transformers and Maximum Demand:

Year	Installed Capacity of Generators (MW)	Installed Capacity of Transformers MVA	Ratio (I.C of Transf. /Gen.)	Maximum Demand (MW)
2010	12470	69824	5.59	10705
2012	13387	76981	5.75	11803
2014	14588	84872	5.81	13012
2016	15778	93571	5.93	14346
2018	17066	103162	6.04	15816
2020	18458	113736	6.16	17438

From Table 5, the expected maximum demand is 17 438 MW in the year 2020. Then MEW is expected to spend (2005 US$/KW) x 17 438 MW =34 963 US$ M. However if half of this cost is spent on PV cells to meet 2.5 % growth rate in maximum demand a considerable decrease in cost of power system expansion.

3. Kuwait Electric Power System:

Kuwait has a hot and long summer period of seven months that extends from April to October with temperatures soaring to over 50 C^0. Weather is generally dry and daily variation in ambient air temperature often exceeds 20 C^0. Cooling for all type of buildings is, therefore essential. As a result, air-conditioning of buildings is the single largest consumer of electricity and it accounts for nearly 75% of nation's peak power demand and over 50% of annual energy consumption. Residential buildings are the major consumer and it is responsible for 42.3% of the total electrical energy consumption as shown in Fig. 1. Table 6 shows how the number of residential consumers was increased and also after diversity maximum demand.

The sharing of different types of consumers in Kuwait is given in Table 7 which shows that the residential sector consumes 42.3 % of total energy consumed by all sectors. This high lights the fact that residential sector should be subsided in building their own PV panels.

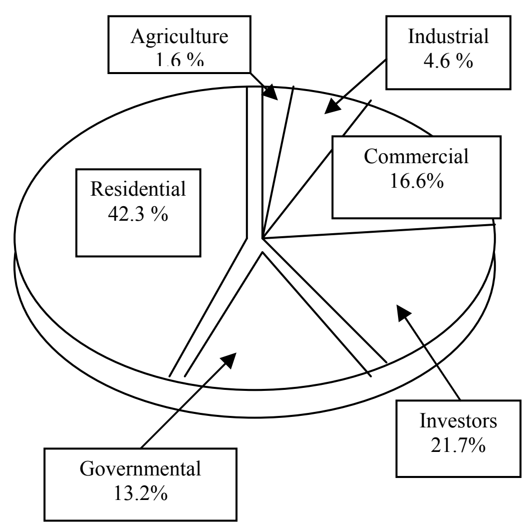
Table 6: Development of number of residential consumers and the maximum demand per consumer

Year	No. of Consumers		Max. Demand of Residential Sector	
	Total	Residential	Total (MW)	KW /consumer
2003	359660	311461	3075	9.87
2004	371031	321758	3177	9.87
2005	375430	332394	3413	10.28
2006	399554	336432	3649	10.84
2007	424781	357484	3815	10.67
2008	432852	364861	3981	10.91

Table 7: Energy consumed for different types of consumers in Kuwait during 2008:

Consumer class	Consumption GWh	Percentage sharing
Residential	309036	42.3
Governmental	96128	13.2
Investors	158822	21.7
Commercial	121333	16.6
Industrial	33738	4.6
Agriculture	11572	1.6
Total	730631	100

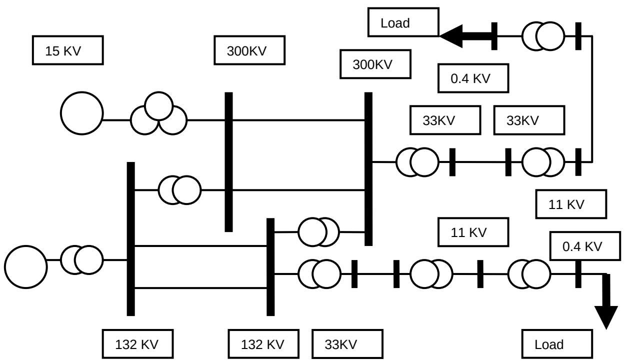
Figure 1: Distribution of Kuwait Electrical Energy Consumption by End-Use Sector:



4. Modeling of Kuwait Power System:

Modeling of Kuwait power system is given in Figure 2

Figure 2: Modeling of Kuwait power system



Kuwait electrical load is characterized by high load in summer and low load in winter according to the increase and decrease in the values of temperatures and relative humidity. The peak load reached 9710 MW on Saturday, 27th of July 2008 at 14:30, with a temperature of 50 C^{o} and relative humidity of 5 %. Kuwait is, at present, covered by vast electric power networks system consisting of overhead lines and underground cables in addition to the primary, secondary and distribution transformer stations that ensure power supply to every consumer.

5. Future Energy Challenge for Kuwait:

Although the 1983 energy conservation code is being applied to all new and renovated buildings, the peak power demand between 1994 and 2008 grew substantially at annual rate of 6.0%, [2, 5, and 6]. MEW is spending nearly 80 million Kuwaiti Dinars at 400 KD/kW (1412 US$/KW) every year to add additional power generation and distribution in the country to meet the growing power demand for A/C systems. Likewise, the amount spent annually on fuel to generate electricity for the operation of the A/C systems is well over 135 million KD (476 million US$) [4, 5, 6]. In addition, there are additional expenditures on manpower and material for the operation and maintenance of the power plants.

In 2009, a contract of US$ 400 Million was signed to design, supply, install, test, and commission 12 large power transformers (400 kV, 765 MVA), low-voltage auxiliary systems and network protection and control equipment. This is has the aim of increasing transmission voltage from 300 kilovolt (kV) to 400 kV. The higher voltage will help strengthen the grid's reliability and increase its capacity to meet rising demand for electricity.

6. End-use Energy Consumption:

Table 8 shows a preliminary estimate for the end-use consumption of a typical villa in Kuwait. The villa is assumed to have an area 600 m^2, and consists of two floors. The average consumption of the villa is assumed to be approximately 4000 kWh per month. The air-conditioning system is switched off during winter months (November – March).

Table 8: End-Use Equipment in a typical private dwelling (villa):

End-use Equipment	No. Of units	Rated Power	Avg. Energy Consumption kWh/month		Annual Energy Consump-tion
		(kW)	Winter	Summer	kWh/yr
Air Condition (Cooling)	1central	8.0	0	4800	33600 (70%)
Refrigerator + Freezer	2 + 1	1.0	250	250	3000 (6%)
Washing Machine	1	2.5	80	80	960 (2%)
Lighting	24x40W 20x100W 0x25W	3..21	578	578	6936 (14.5%)
Water Heater	4	4	480	0	2400 (5.0%)
TV/Video	2	0.25	45	45	540 (1.0%)
Miscellaneous	---	---	60	60	720 (1.5%)
Total		18.96	1370	5745	48156 (100%)

The air condition is operated only in hot weather (7 months). From Table 8 the total installed capacity per residential consumer is 18.96 KW while the calculated maximum demand during the year is 10.91 KW. This means that the diversity factor is 0.575.

Assuming that the load (after maximum demand) of one freezer 0.3 KW and of lights 1.0 KW can be meet by PV cells. This involves connected them directly to the DC circuit as shown in Figure 3. The advantages of this connection are avoiding losses in transmission and distribution, release the power system capacity, alleviate the problem of voltage drop and improving the overall power factor.

At this stage only 1.3 KW is considered to be a practical assumptions due to many constraints. With the present PV technology and panels the area needed to meet the total after maximum demand 10.89 KW will be very large and expensive. Also it is hoped that in the future the panels and PV cells will be more affordable due to technological development and mass production.

Solar power systems that are connected to the electricity grid otherwise known as grid connected, grid tied, or on-grid photovoltaic systems. These generate electricity for domestic premises work and feed excess energy produced back into the electricity grid system.

Grid connected systems are designed to replace all or a portion of the building's total electricity needs. The energy generated by such a system is used first within the home, and surplus energy can then be sold back to the grid. The surplus energy "spins the electric meter backwards" when the energy produced by the solar PV system is greater than that being consumed by the home. In actual fact the utility company will normally install an export meters which measure the amount of electricity generated by the solar PV system.

In this paper the grid tie solar power kits include solar modules as given in Table 9. Each system is provided with complete solar modules, solar mounting frames, wiring, combiner box, inverter, DC and AC isolating switches and circuit breakers.

There are two possibilities of grid connect systems, those without battery backup and those with battery backup. The present design shown in Fig 3 is a grid connected systems without a battery consist of two main components, a solar PV array and a grid-connect inverter. If the utility grid fails then the solar PV array has no way of providing power as the inverter will automatically disconnect itself from the utility grid. The grid-tied systems with a battery backup also have an array and a grid-tied inverter, but this implies additional battery bank and charge controller, therefore it was excluded from this design. Systems with a battery bank can provide power in the event of the electricity (utility) grid failure.

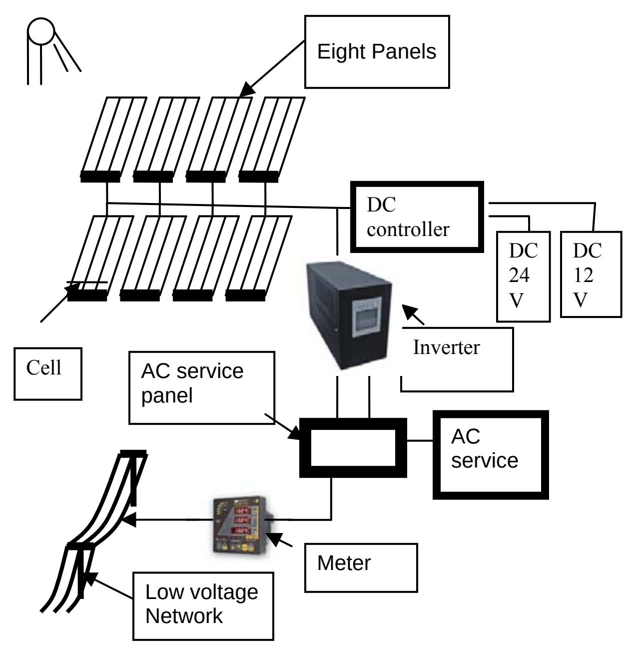
There grid connected system is simple to install, having a higher efficiency, reliable and more flexible. A typical household installation has a number of essential components that comprise the solar photovoltaic system. Solar panels one or more modules wired together to generate a specific voltage and current. The combiner (junction) box allows termination of the solar panels, and the grid tie inverter - device that converts DC (direct current) to AC (alternating current). The import / export meter - records energy generated and consumed. And the grid connect point - distribution board connection

In this grid-tied solar system, the DC electricity produced by the solar array is fed by cables into a combiner (junction) box where the solar panels are terminated and connected together. A cable from the combiner box feeds the DC electricity into a grid-tied inverter. The inverter converts the DC electricity into AC electricity which is used by the appliances or fed into the grid. The output from the inverter is fed via a fuse directly into the main distribution (fuse board).

Table 9: Cost of grid tie solar power kits suggested to be used by single consumers

No. of solar panels	Peak output (Watts)	Annual output based on 9 hrs in Summer and 5 hrs in Winter (KWh)	Rated power of each panel (Watts)	Price (US$)
8	1680	5019+2788=7807	210	4000

Figure 3: The new design with a low voltage network connection:



Solar modules collect energy from the sun and transform it into Direct Current (DC). The DC travels through the inverter where it is then converted to Alternating Current (AC) (Generally household appliances use AC). The meter keeps track of the AC energy which photovoltaic (PV) system produces and if the energy produced is more than the demand, that excess energy goes back onto the grid through the power lines. When this extra (AC) power goes back onto the grid, the electric meter spins backwards, essentially giving you credit for when the sun goes down and you still need electricity. A relatively small number of urban solar systems are off grid which means they are not connected to the grid and consequently do not send any (AC) power back onto the grid. These systems store their excess energy in batteries. A battery back-up system generally adds 15% to the cost of a residential PV system.

Let P_{PV} = DC load in KW which can be meet by PV cells per residential consumer by splitting his installation into d-c and a-c circuits.

L_{TR} = Transmission losses

L_D = Distribution losses

P_{PVE} =Equivalent AC load sent out from AC generation station

$= P_{PV} + L_{TR} + L_D$

N_{RES} = Total number of residential consumers

D_{RES} = Diversity factor for residential consumers

P_{RL} = Real power of residential load

Then

$$P_{RL} = P_{PVe} \times D_{RES} \times N_{RES}$$
$$= (P_{PV} + L_{TR} + L_D)\, D_{RES} \times N_{RES}$$
$$= (1.3 \times 1.14) \times 364861 \times 0.6 = 324.4 \text{ MW}$$

It is worth mentioning that recently the concentric PV solar plant project cost Masdar (UAE) $600 million to generate about 100 megawatts of power. The plant, with 768 parabolic mirrors, will be the largest concentrated solar power plant in the world, extending over a 2.5-square-kilometer area. In this case the cost of 1 KW is equal to US$ 6000 which means that this is expensive solution because the DC power generated is inverted to AC power and transformed up to link the grid at high voltage.

7. Energy losses calculations and cost for Kuwait power system:

Software developed by the first author was used to calculate energy losses in power system networks by repeating the load flow during 48 hours and including the effect of daily, weekly and seasonal variation of load.

-Methodology of energy losses calculations

The losses in each element of the system were found as a result of the load flow solution based on the Newton Raphson (**NR)** method. According to **NR** the net injected active and reactive powers at node *k* are given by:

$$P_k = V_k \sum_{q=1}^{n_b} V_q \left(G_{kq}\cos\theta_{kq} + B_{kq}\sin\theta_{kq}\right) \qquad (1)$$

$$Q_k = V_k \sum_{q=1}^{n_b} V_q \left(G_{kq}\sin\theta_{kq} - B_{kq}\cos\theta_{kq}\right) \qquad (2)$$

Where $\theta_{kq} = \theta_k - \theta_q$

The linear equations 3 and 4 are appearing in Newton's formulation is given by:

$$\begin{bmatrix}\Delta P\\ \Delta Q\end{bmatrix} = \begin{bmatrix} H & N\\ M & L\end{bmatrix}\begin{bmatrix}\Delta\theta\\ \Delta V/|V|\end{bmatrix} \qquad (3)$$

The sub matrices *H*, *N*, *M*, and *L* represent the Jacobian matrix of partial derivatives of the mismatch powers ΔP and *ΔQ* with respect to proper angles θ's and voltage magnitudes *V's.* The real and reactive power flow from bus *k* to bus *q* can be expressed as:

$$P_{kq} + jQ_{kq} = V_k(V_k^* - V_q^*)y_{kq}^* + V_k V_k^* \left(\frac{y'_{kq}}{2}\right)^* \qquad (4)$$

Alternatively, the real and reactive power flow from bus *q* to bus *k* can be expressed as:

$$P_{qk} + jQ_{qk} = V_q(V_q^* - V_k^*)y_{kq}^* + V_q V_q^* \left(\frac{y'_{kq}}{2}\right)^* \qquad (5)$$

Therefore the power loss in segment *kq* is given by:

$$P_{Lkq} = \mathrm{Re}(S_{kq} + S_{qk}) \qquad (6)$$

Figure 4: Division of suitable number of equal or unequal periods of time

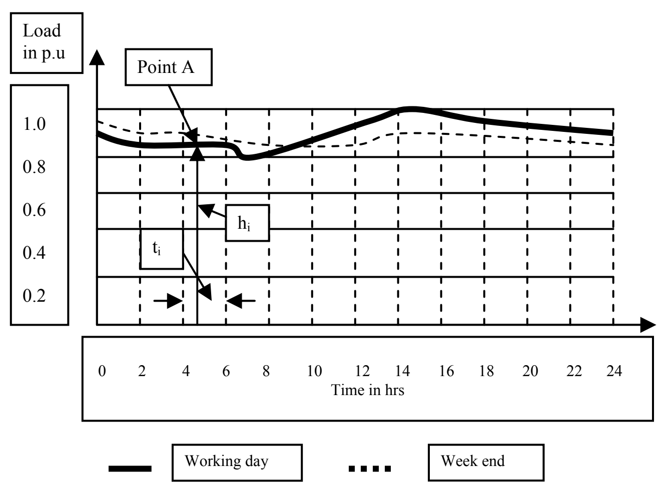


Figure 4 shows that the total period of the day for a particular *j*th season(s_j) of the year, is divided into a suitable number of equal or unequal periods of time such that: h_i= period of time for the ith load at point (A).

t_i = time of ith load at point (A)

And $\sum_{i=1}^{T} (h_i) = 24$ hrs (7)

Then the energy consumed during the period h_i and season s_j is

$$E_{hi} = P_k(t_1, s_j)\,(h_i) \qquad (8)$$

The energy loss during the period h_i

$$E_{Lhi} = P_{Lkq}\,(h_i) \qquad (9)$$

From the load flow the power losses are calculated at that instant of time. The daily energy consumed and energy losses in each segment of the system are given by:

$$E_d = \sum_{i=1}^{T} P_k(t_i, s_j) \bullet h_i \qquad (10)$$

And
$$E_{dl} = \sum_{i=1}^{T} P_{Lkq}(t_i, s_j) \bullet h_i \qquad (11)$$

In similar steps the real and reactive power are specified for any node k and at any time t_i using the weekend specified load. And then the load flow solution is repeated again for all the periods of the weekend. Also the same for E_{dw} and E_{dlw}

As the historical data of the energy consumed during each season of the year are specified; then the seasonal factor SF_{sj} for any season s_j of the year is defined as follows:

$$SF_{sj} = E\,(s_j) / E(s_1) \qquad (12)$$

Where $E(s_1)$ is the energy of the reference season.

If $N_r(s_j)$ and $N_w(s_j)$ are the number of workdays and weekends respectively, then the calculated seasonal energy losses are given by:

$$E_{sl}(s_j) = (E_{dl})(N_r(s_j)) + (E_{dl})(N_w(s_j)) \qquad (13)$$

Then the calculated annual energy losses are

$$E_{al} = \sum_{j=1}^{4} E_{sl}(s_j) \bullet (Sf_{sj})^2 \qquad (14)$$

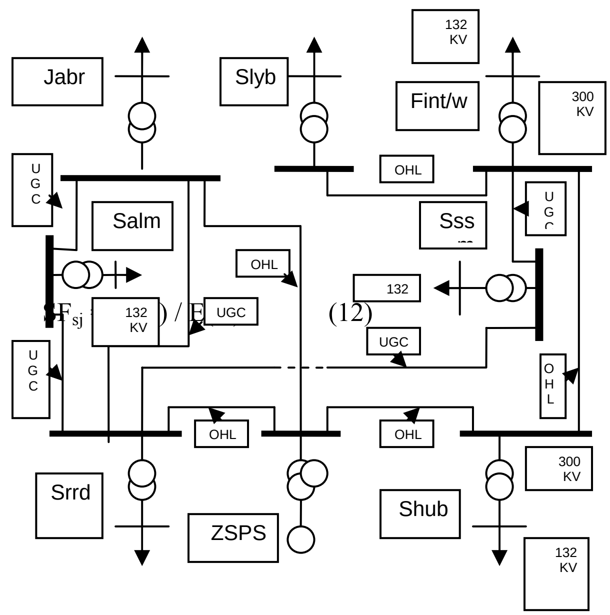
-Results of calculations

Due to a limited time devoted for this project, we consider only a part of Kuwait national grid (20%) operating in 300KV and 132 KV and as given in the single line diagram shown in Figure 5. The calculation of losses for all system can be estimated as given in Table 10.

Table 10: Calculated peak losses in different parts of Kuwait power network:

Year	Max. Demand at grid stations (MW)	Trans. losses (MW) at 4. 6 %	Distribution losses (MW) at 9.4 %	Max. Demand at distr. (MW)
2008	9710	446.66	912.74	8350.6
2010	10705	492.43	1006.27	9206.3
2012	11803	542.93	1109.48	10150.5
2014	13012	598.55	1223.12	11190.3
2016	14346	659.91	1348.52	12337.5
2018	15816	727.53	1486.70	13601.7
2020	17438	802.14	1639.17	14996.6

Figure 5: Part of Kuwait power system:



8. Conclusion

In comparing the concentric PV solar plant to this new distributed micro generation PV panels has a cost of nearly four times. Beside the distributed has a higher reliability than the concentric one. Also it easier to install and the separation of the installations can be done so easily. Dealing with lower voltages especially for low power consumption appliances within the premises of the residential consumers, can save unnecessary energy losses occurring in the electric power networks starting from the point of generation up to the point of consumption.

Feed-in Tariffs (FITs)
A new tariff may be introduced on applying this type of micro generations. This new scheme requires electricity suppliers to pay householders and communities who generate their own electricity from renewable or low carbon sources such as solar electricity (PV) panels or wind turbines. Residential consumers will benefit in three ways:

1. **Generation tariff** – a set rate paid by the electricity supplier for each unit (or kWh) of electricity you generate. This rate will change each year for new entrants to the scheme (except for the first 2 years), but once the consumer join he will continue on the same tariff for 20 years, or 25 years in the case of solar electricity (PV).
2. **Export tariff** – the consumer will receive a further 3p/kWh from his electricity supplier for each unit he export back to the electricity grid, that is when it isn't used by him.. This EXPORT rate is the same for all micro-generation technologies.
3. **Reduction of electricity bill** –savings on the electricity bills because the consumer is using the electricity he produce so reducing the amount of electricity he buy from his provider.
4. **Low Voltage DC for domestic is the future**

-Low voltage DC 12V/24- Lighting

The new types of lighting should be employed that depends on a new technology of very low power consumption LED lightings, are designed to optimize the lighting requirements and they are the future of the illumination that is applicable on the streets and houses. These are superbly decorated designed and packaged as integrated ballast lamps which are very durable and can be switched on-off thousands of times without any decrease in efficiency. For example Energy Saving Lamp 11W, 12V and 7W, 12V

-Low voltage fridges for boats, yachts, caravan and motor homes

There is a wide range of superb 12V/24 Volt batteries operated (Low Voltage) Fridges and Freezers for use on Boats, Yachts, Cruisers, Motor homes, Caravans, Horseboxes & Trucks. This low dc voltage range of equipments may be modified in a certain way to be utilized in the residential houses meeting the proposed idea in this paper

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